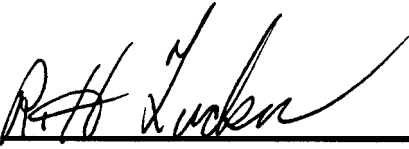




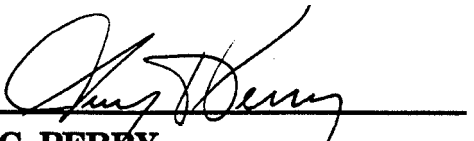
**RELIABILITY PLAN
FOR
SPACE SHUTTLE
SOLID ROCKET BOOSTER ASSEMBLY PROJECT.**

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PREFACE

This document describes the reliability **provisions necessary** to comply with the Data Requirement **(DR) RA-01** and NHB 5300.4 **(1D-2)**, Safety, Reliability, and Quality **provisions** for the Space Shuttle Program, for operations of USBI as required by Data Procurement Document **SE-019-200-2H** of Contract NAS836300.

The requirement for use of the International System of Units has been waived for this document.

Document Number RA-01
As of 02-28-95
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DCN Number	ECP Number	DCN Date	Pages Affected	Item Affected	
---	---	---	ALL	REVISION: Basic APPROVED: April 5, 1985 AUTHORITY: SA43(85-143)TA	
---	---	---	ALL	REVISION: Basic for Restructure (Ref: BPG007-87) APPROVED: September 7, 1988 AUTHORITY: SA43(88-643)DN	
---	---	---	ALL	REVISION: A APPROVED: December 16, 1992 AUTHORITY: AP48(QZ-1077-92)DS	
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ABBREVIATIONS AND ACRONYMS

BAC	Booster Assembly Contract
CDR	Critical Design Review
CFE	Contractor Furnished Equipment
CIL	Critical Items List
CoFR	Certification of Flight Readiness
COQ	Certificate of Qualification
DR	Data Requirement
EEE	Electronic, Electrical, Electromechanical
FMEA	Failure Mode Effects Analysis
FRR	Flight Readiness Review
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
HSV	Huntsville, Alabama
JSC	Johnson Space Center
KSC	Kennedy Space Center
MRB	Material Review Board
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
OMD	Operation and Maintenance Document
OMRSD	Operational Maintenance Requirements and Specification Document

ABBREVIATIONS AND ACRONYMS (Continued)

PAS	Problem Assessment System
PDR	Preliminary Design Review
PRR	Preliminary Requirements Review
SOW	Statement of Work
SRI3	Solid Rocket Booster
SR & QA	Safety, Reliability and Quality Assurance
USBI	A Division of United Technologies Corporation

1.0 INTRODUCTION

1.1 Purpose

The Reliability Plan for the Solid Rocket Booster Assembly and Refurbishment Program is submitted in accordance with Data Requirement (DR) **RA-01** and meets the requirements set forth in NHB 5300.4 (1D-2) and **CEI** Specification **10CEI-0001**.

This plan will be reviewed by USBI periodically. When a revision is required, USBI will initiate the change which will be submitted to MSFC for approval prior to implementation.

The Safety, Reliability and Quality Assurance (SR & QA) Director will be responsible for the implementation of all aspects of reliability policy. **Figure I-1** reflects the organizational approach which will assure continuity and compatibility of requirements. The SR & QA Director reports directly to the USBI Executive Vice President and General Manager.

1.2 Scope

This Reliability Plan describes the implementation of requirements contained in Chapter 3, "Reliability" of NHB 5300.4 (1D-2). It also defines the USBI Reliability organization, interfaces, and responsibilities proposed to meet the requirements of the operational phase of the SRB Program.

1.3 Reference Documents

NASA DOCUMENTS

NHB 5300.4 (1D-2) Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program.

1.3 Reference Documents (Continued)

NASADOCUMENTS

MSFC-SPEC-549	Guidelines for Performing Failure Mode Effects Analysis (FMEA) on Mechanical, Electrical, and Electromechanical Components
10REQ-0021	Solid Rocket Booster Assembly Checkout Operations and Maintenance Requirements and Specifications Document
NSTS-08171	Volume III, File V - Retrieval and Disassembly Operations and Maintenance Requirements and Specifications
NSTS-22206 REV. A	Space Shuttle Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL) Groundrules
10CEI-0001	Contract End Item Specification, Part I, Solid Rocket Booster Operational Flights (STS-7 and Subs)
85M03936	EEE Parts Selection and Application Guidelines for the Space Shuttle External Tanks and Solid Rocket Booster
MIL-STD-975	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List

RELIABILITY DATA REQUIREMENTS DOCUMENTS

RA-01	Reliability Plan
RA-02	NASA Alert System Documentation
RA-03	Limited Life Item List
RA-04	Parts Substitution and Deviation Request
RA-05	Where Used Parts List
RA-06	Problem and Resolution Report
RA-07	Failure and Unsatisfactory Condition Summary Report
RA-13	Materials and Component Qualification Test Procedures
RA-14	Certificate of Qualification
RA-19	Qualification Test Report
RA-20	Failure Mode and Effects Analysis (FMEA)
RA-21	SRB and Range Safety Command Destruct System Critical Item List (CIL)

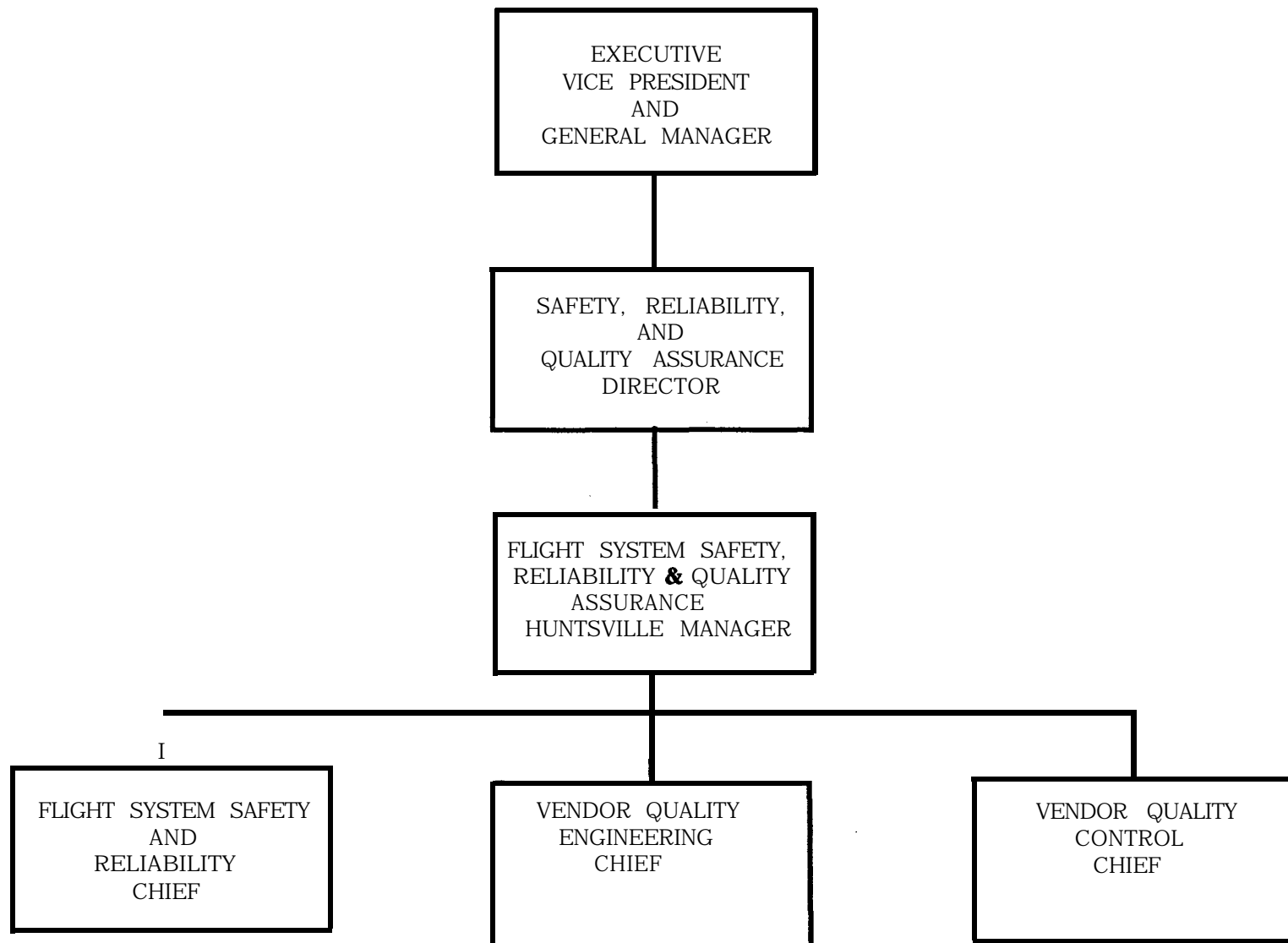


FIGURE 1-1 RELIABILITY ORGANIZATION

2.0 **ORGANIZATION AND RESPONSIBILITIES**

21 **USBI Huntsville** Operations

USBI maintains a reliability activity which is an integral part of design, development, and manufacturing processes and includes the evaluation of hardware reliability through analysis, review, and assessment. Timely status reporting is utilized to facilitate control of the reliability effort.

The Reliability Chief (see Figure 1-1) is responsible for ensuring that reliability functions are performed according to USBI and NASA reliability policies as outlined in NHB 5300.4 (1D-2) and this plan. USBI Reliability Engineering **and/or** Vendor Quality Control performs Reliability Audits of selected Vendors. USBI Engineering, Program Management and Procurement Organizations provide support to Reliability Engineering for the review and closure of Alerts and Problem Assessments. The Engineering Organization also provides support in the areas of EEE parts reports, development of Certificate of Qualifications, and the development of **FMEA/CIL's**. Reliability Engineering monitors the reliability tasks performed by other organizations to assure effective accomplishment of the overall reliability task. Deliverable items required by NASA are shown on the Reliability Milestone Chart, Table I.

2.2 **USBI Florida Operations**

USBI Florida Operations Quality Assurance performs the Reliability Engineering functions for Limited Life Items Status Reports/Reviews, Alert reviews for USBI Florida Operations, production of Failure and Unsatisfactory Condition Summary Report and in house audits of USBI Reliability Engineering functions. Each of the Reliability Engineering functions performed is monitored by the Reliability Engineering Chief to assure effective accomplishment of the reliability task.

TABLE I RELIABILITY MILESTONE CHART

	<u>TASKS</u>	<u>DR</u>	<u>REQUIRED SUBMITTAL DATES</u>
1.	Reliability Plan	RA-01	60 days after contract award. Update as required
2.	NASA Alert System Documentation	RA-02	Respond within 21 work days after receipt. Contractor initiated alerts submitted within 5 work days of reportable problem.
3.	SRB Equipment Requiring Log Books and Limited Life Items List	RA-03	Update, as required, to keep document current.
4.	Part Substitution Deviation Requests	RA-04	21 days prior to change, and deviation, or substituted part installation.
5.	Where Used Parts	RA-05	60 days prior to design List review of CFE. Update as required.
6.	Problem and Resolution Report	RA-06	Facsimile report within 48 hours, documented report within 5 days, and resolution report upon completion of failure analysis and other actions required for recurrence control.

TABLE I RELIABILITY MILESTONE CHART (Continued)

7.	Failure and Unsatisfactory Condition Summary Report	RA-07	Monthly, to arrive at destination by tenth day of the month.
8.	Materials' and Qualification Test Procedures	RA-13	To arrive at destination within three weeks prior to start of each Qualification Test.
9.	Certificate of Qualification	RA-14	At time of qualification for each component or subsystem requiring qualification.
10.	Qualification Test Report	RA-19	30 days after completifm of Qualification Testing.
11.	Failure Mode and Effects Analysis (FMEA)	RA-20	System level - Update as required (a minimum of once per year) to support FRR. Component Level - Submitted with CDR Data Package.
12.	SRB and Range Safety Command Destruct System Critical Items List (CIL)	RA-21	Update as required (a minimum of once per year) to support FRR.

3.0 APPROACH

3.1 **Reliability Management (1D300)**

3.1.1 Reliability Plan

The Reliability Plan is prepared and updated in accordance with DR RA-01. The plan will be revised when required and submitted to Marshall Space Flight Center (MSFC) for approval.

3.1.2 Reliability Audits

Reliability audits of internal activities and the activities of major suppliers are conducted (by SR & QA audit teams) to evaluate progress and effectiveness of the Reliability Program. Internal audits are limited to departments performing reliability tasks. A schedule is maintained by the SR & QA organization of planned audits. Reliability audits of suppliers may be combined with Safety and Quality Assurance audits. The frequency of audits is based on complexity of hardware, supplier experience, hardware cost, criticality of hardware, and hardware use.

3.1.3 Progress Reporting

Progress of the reliability effort is reported periodically to MSFC and project management through activities such as Management Meetings, SR&QA Reviews, and Flight Readiness Reviews.

3.1.4 supplier control

During procurement of Contractor Furnished Equipment (CFE), Reliability Engineering ensures that adequate reliability requirements are imposed on suppliers. The level of reliability requirements imposed on suppliers is appropriately tailored to be consistent with those imposed on USBI and shall consider complexity, supplier experience, hardware unit cost,

3.1.4 Supplier Control (Continued)

hardware use, and criticality. When procuring off-the-shelf hardware, Reliability Engineering examines historical data, failure mode effect analyses, critical items lists, problem reports, alerts, failure analyses, Electrical, Electronic, and Electromechanical (EEE) parts, specifications, test reports (Qualification, Certification, and Acceptance Tests), design data, and other available reliability data to ensure acceptability for SRB application.

3.1.5 Reliability of Government ~~Furnished~~ Equipment (GFE)

Reliability Engineering is responsible for the identification of reliability data needed for GFE to be incorporated into SRB design by USBI. When examination of data or testing by USBI indicates inconsistency of the reliability of the GFE with the reliability requirements of the overall system, MSFC is formally notified.

3.2 Reliability Engineering (1D301)

Reliability Engineering accomplishes the following tasks on flight equipment and, as specified, on flight GFE.

3.2.1 Reliability Design Criteria

The Reliability Design Criteria prepared by Reliability Engineering will be maintained. This document, furnished to Engineering for use during SRB design, is also used by Reliability Engineering to evaluate new designs and changes. The reliability design criteria were developed from NASA Level I, II, and III requirement documents. The document is updated as required to reflect changes in the Level I, II, and III requirements.

3.2.2 Trade Studies

Reliability Engineering will participate in design trade studies and prepare and utilize reliability numerical estimates as appropriate. Numerical estimates will include failure rates, mean time between failures (**MTBFs**) and predictions.

3.2.3 Failure Mode and Effects Analysis (FMEA)

USBI Reliability Engineering maintains the system level SRB and Range Safety Command Destruct System **FMEA** and updates the component level **FMEAs** in accordance with "Space Shuttle Failure Mode and Effect Analysis (FMEA) and Critical Items List (CIL) Groundrules" document, NSTS-22206 Rev. A.

The system level SRB and Range Safety Command Destruct System FMEA meets the requirements of NHB 5300.4 (**1D-2**) and was performed using NSTS-22206 Rev. A. "Instructions for Preparation of Failures Modes and Effects Analysis (FMEA) and Critical Items List (CIL)", as a guide. The FMEA documents qualitative reliability analysis, identifies failure modes and their effects, and classifies the failure mode criticality.

Changes to the **FMEA/CIL** analysis may be accomplished on a periodic basis to be submitted a minimum of once per year. However, any change which is classified as "Immediate" per NSTS 22206 or MSFC SRB Project Office guidelines will be submitted on a per flight basis.

The SRB and Range Safety Command Destruct System FMEA is revised as necessary to meet program requirements. Changes will be accomplished by change pages or by a complete reissue in accordance with DR RA-20. The FMEA is utilized for test and inspection planning to ensure that critical failure modes are adequately tested and inspected. Component level

3.2.3 Failure Mode and Effects Analysis (FMEA) **(Continued)**

FMEAs are prepared or updated as required on criticality 1, **1R**, hardware, for which the contractor has design responsibility, to reflect design changes, using NSTS 22206 Rev. A, "Guidelines for Performing Failure Mode Effects Analysis (FMEA) on Mechanical, Electrical, and Electromechanical Components", as a guide.

36.4 critical Items List (CIL)

The CIL documents and provides waiver retention rationale for the critical SRB and Range Safety Command Destruct System failure modes and effects identified in the SRB and Range Safety Command Destruct System Level FMEA. The CIL meets the requirements set forth in NSTS-22206 Rev. A ("Space Shuttle Failure Mode and Effect Analysis (FMEA) and Critical Items List (CIL) Groundrules").

The CIL meets the requirements of NHB 5300.4 (**1D-2**) and was performed using NSTS 22206 Rev. A, "Instructions for Preparation of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)", as a guide. The CIL is revised on an "Immediate" basis as necessary for each flight and on a "Periodic" basis (a minimum of once per year) for those changes not meeting the requirements for immediate submittal. CIL changes will be accomplished by change pages or by a complete reissue in accordance with DR RA-21.

USBI will utilize the CIL for test and inspection planning to ensure that critical failure modes of items in the CIL are adequately tested, inspected, and identified in document **10REQ-0021**, "SRB Assembly Checkout Operations and Maintenance Requirements and specifications", and in document NSTS 08171, "Volume II, File V - Retrieval and Disassembly Operations and Maintenance Requirements and specifications".

3.2.5 Log Books and Limited Life Items

The SRB equipment requiring log books and limited life items list will be maintained in accordance with DR RA-03. The time/cycle/age limited life items which require control from date of manufacture throughout operational use, storage, and refurbishment are identified by Reliability Engineering and tracked ~~by USBI Florida Operations Quality Assurance~~. Provisions are made to notify personnel responsible for the equipment when remaining duty cycles will not support planned usage. USBI Florida Operations Quality Assurance compiles a status report of limited life items which is supplied to NASA as a part of the **CoFR** review process.

3.2.6 Design Review and Readiness Review

Reliability Engineering supports SRB Preliminary Requirements Review (PRR), Preliminary Design Review (PDR), and Critical Design Review (CDR) on new design changes for hardware under USBI design responsibility.

The Reliability Design Criteria document referenced in paragraph 32.1 is used by Reliability Engineering to assure that reliability requirements are implemented into the design. Each engineering design change is assessed by Reliability Engineering to determine the effects of the proposed change on the overall design.

Reliability Engineering supports Flight Readiness Reviews (FRR) by providing **FMEA/CIL** changes, status of Alerts, open problem reports, and certificate of qualification status.

36.7 **Problem Reporting and Corrective Action**

USBI maintains a closed-loop system for failure/unsatisfactory condition reporting, nonconformance reporting, and recurrence control. All SRB hardware and computer software under the jurisdiction of USBI are subject to these reporting systems.

Reliability Engineering is responsible for ensuring that problem reporting and corrective action of vendors comply with contractual requirements imposed on USBI.

Failure and unsatisfactory condition reports are prepared on all observed or suspected non-conformances and an open problem status list is maintained with monthly status reports submitted to MSFC. USBI notifies NASA of problem isolation within 48 hours and a copy of the problem report is submitted within five working days of a reportable item identification. A copy of the problem resolution is submitted upon completion of failure analysis and other actions required for recurrence control.

An analysis of each problem reported to MSFC is performed to determine the cause of the problem and to implement adequate measures to prevent its recurrence. Primary emphasis is placed on hardware **teardown** analysis. However, where the cause of the problem is understood or where sufficient prior analysis has been obtained, additional hardware **teardown** is not performed. **Teardown** analysis of hardware or the return of hardware to the vendor for failure analysis is controlled by Material Review Board (MRB) action.

All criticality **1**, **1R**, and functional failure category **3** hardware problem reports, beginning with acceptance testing, are reported to the MSFC Problem Assessment System (PAS). Problem reports and the Failure and Unsatisfactory Condition Summary Report will be submitted in accordance with DR RA-06 and DR RA-07, respectively.

38.8 Reporting and Resolving NASA Parts and Material Problems (Alerts)

Problems with parts or materials used in equipment which are of mutual concern to NASA and USBI are reported utilizing the NASA Alert System DD Form 1938. USBI has an established, systematic approach to evaluating and responding to NASA Alerts. Where Used Part Lists are reviewed and appropriate vendors and USBI personnel are notified when an Alert is received to determine impact to the SRB Program. Reliability coordinates the investigation, resolution, and documentation of parts and material problems. Alerts provided by MSFC are reviewed by Procurement to assure that lots, batches, or other groupings of hardware noted as suspect are not used in the future. Response to MSFC transmitted Alerts is initiated by Reliability Engineering so as to arrive at MSFC within 21 working days of receipt as required per DR RA-02.

3.2.9 Electrical, Electronic, and Electromechanical (EEE) Parts Control

Reliability Engineering maintains a EEE Parts Control Program. The USBI Engineering organization conducts material specifications and applications reviews on all parts and materials procured by USBI. Reliability Engineering ensures that EEE parts, Parts Substitution and Deviation Requests, and Where Used Parts List requirements are included in suppliers' **SOWs** when required. Parts Substitution and Deviation Requests and Where Used Parts Lists are submitted to MSFC in accordance with DR RA-04 and DR RA-05, respectively, for CFE. EEE parts specifications prepared by USBI for the SRB Flight hardware are identified by a unique number and will be controlled. The specifications are submitted to MSFC with the Parts Substitution and Deviation Request. USBI utilizes **85M03926** "EEE Parts Selection and Application Guidelines for the Space Shuttle External Tank and Solid Rocket Booster" and **MIL-STD-975** (NASA), "NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List", when procuring parts.

3.2.10 **Materials Specifications and Application Reviews**

USBI reviews design specifications to assure compliance with all required materials specifications. Material applications are reviewed for compliance with flammability and material specifications.

3.3 **Testing (1D302)**

3.3.1 **Certification**

SR & QA monitors and supports the certification program established to demonstrate that the hardware, as designed, assembled, and checked out is capable of meeting its requirements, including refurbishment and **re-use**. The Certification of Flight Readiness (**CoFR**) log is the principle record which denotes SRB flight readiness. The **CoFR** log of exceptions is attached to the **CoFR** for the purpose of recording exceptions and their resolutions. The description of the exception includes the plan and schedule of resolution and is updated with descriptions of the resolution of the exception as available. USBI assures that adequate documentation is maintained to substantiate and track activities in meeting certification requirements. Material and component qualification test procedures, qualification test reports, and certificates of qualification are prepared and submitted to MSFC in accordance with DR **RA-13**, DR RA-19, and DR **RA-14**, respectively. Certificates of Qualification (**COQ**) are prepared by Engineering and data is verified by Reliability Engineering and approved by Program Management.

3.3.2 **Acceptance Testing**

SR & QA, in conjunction with Engineering, reviews all acceptance test requirements to assure that they are adequate for performance verification and to detect manufacturing defects. Work authorization documents are reviewed against **OMRSDs**, **CILs**, and other acceptance test requirements to assure that hardware is adequately tested.